Systems Analysis and Concepts Development for Space Exploration and Science

Ajay Kumar

Director, Systems Analysis and Concepts Directorate

October 26, 2007

Systems Analysis: An Upfront Component of Systems Engineering

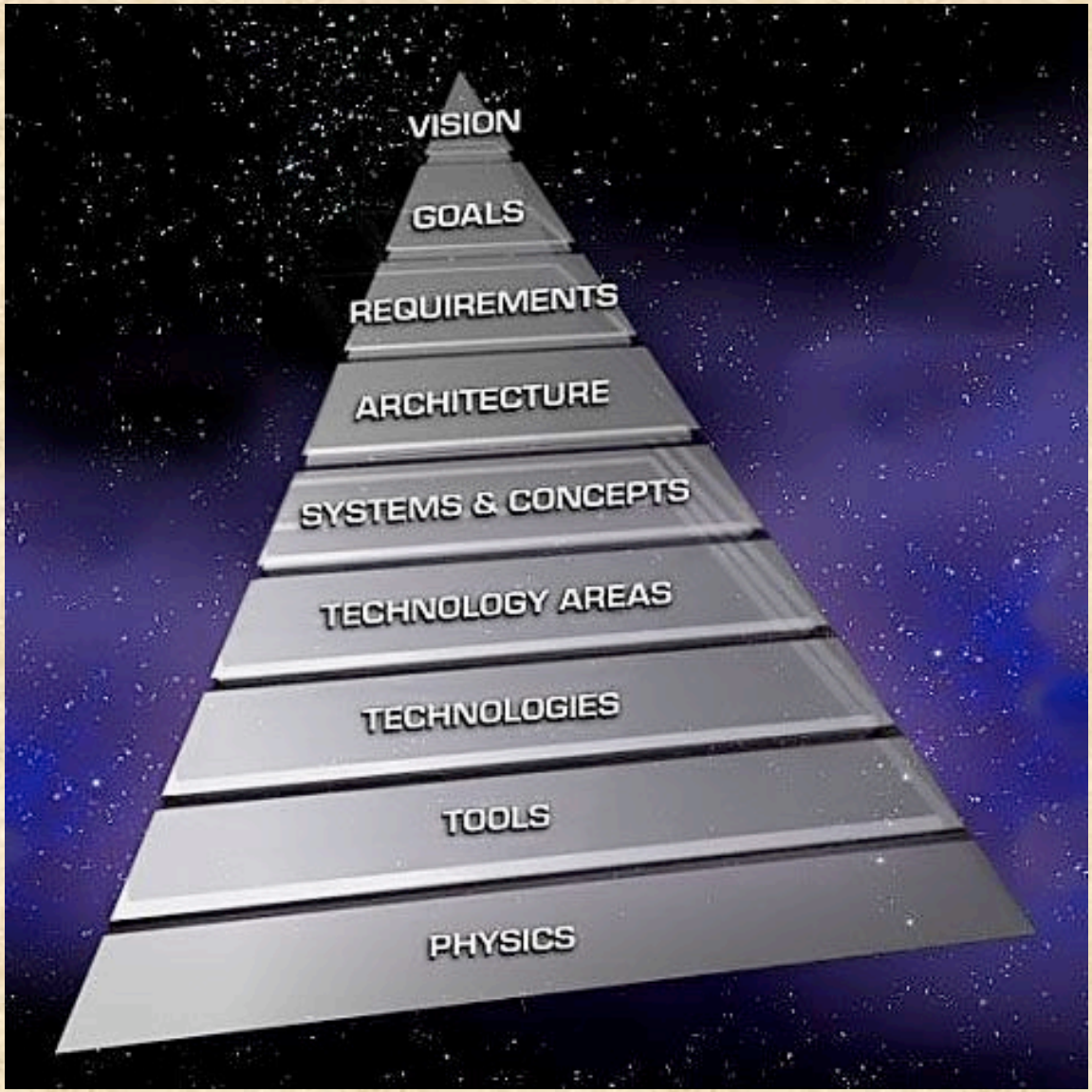
The process of systems analysis consists of the following:

- Vision (e.g., Vision for Space Exploration)
- Goals and requirements (Derived from high level vision)
- Mission architectures and systems concepts (Approaches for achieving goals and requirements; consists of systems and concepts integrated into a concept of operation)
- Systematic assessment and prioritization of capabilities and technologies based upon figures of merits spanning performance, cost, risk, and schedule
- Capabilities and enabling technologies (e.g., structural concepts, propulsion concepts, EDL, etc. and individual technologies that enable these capabilities such as advanced materials, precision landing, etc.)
- Assessment of individual technologies for
  - Desired performance requirements
  - Readiness levels
  - Developmental costs
  - Systems performance benefits due to insertion of new technology compared to original technology

  to guide investment strategies in technologies

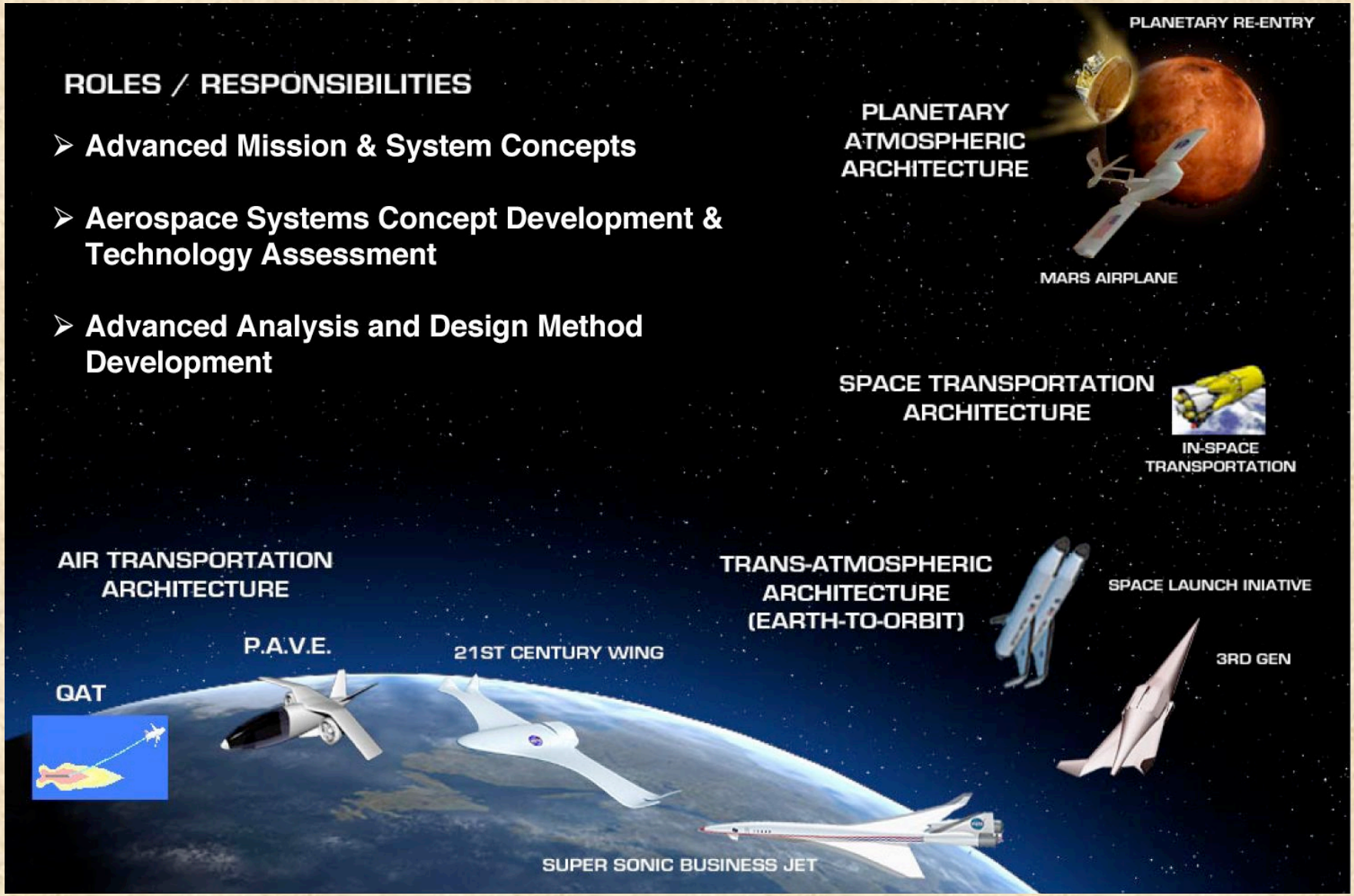
Analytical tools link the fundamental vision, architectures, supporting systems, and technologies down to basic physics

Hierarchy in Systems Analysis Process



Systems Analysis and Concepts

Conduct studies for Agency decision makers and programs to provide aerospace systems analysis products such as mission architectures, advanced system concepts, system and technology trades, life cycle cost and risk analysis, system integration and pre-decisional sensitive information to enable informed technical, programmatic and budgetary decisions

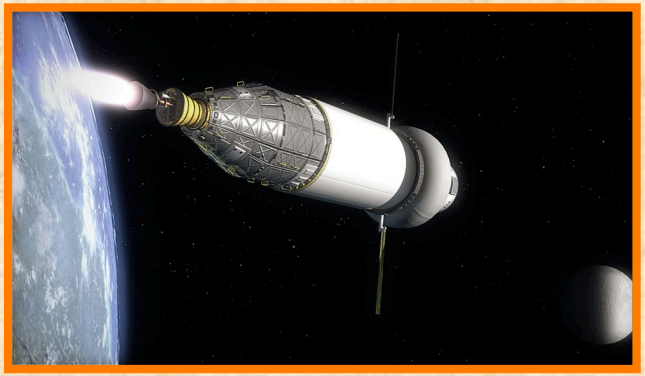


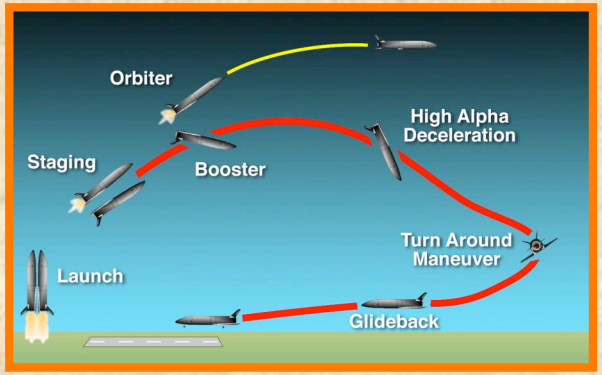
Advanced Mission, System Concepts, & Architecture Studies

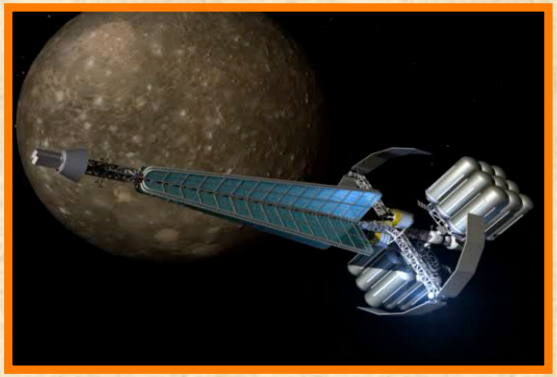
The conception, development, and planning of advanced aerospace missions and systems using advanced operations and system analyses that integrate contributions of required technical disciplines and systems

Products

- Mission Requirements
- Mission architecture and systems concepts
- Mission operational analysis
- Mission life cycle analysis

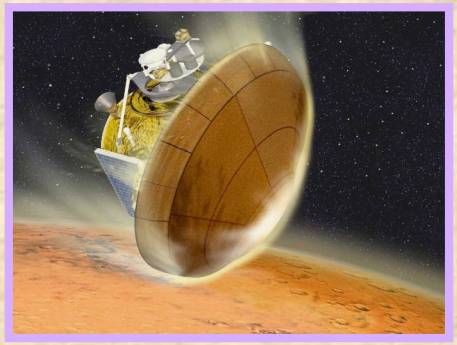






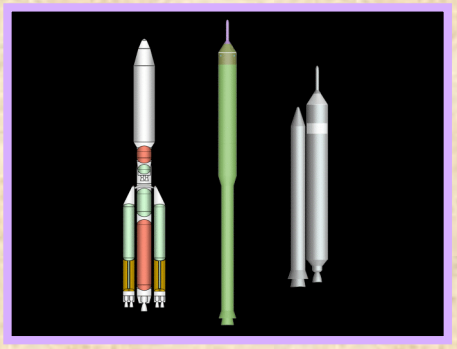
Aerospace Systems Concept Development & Technology Assessment

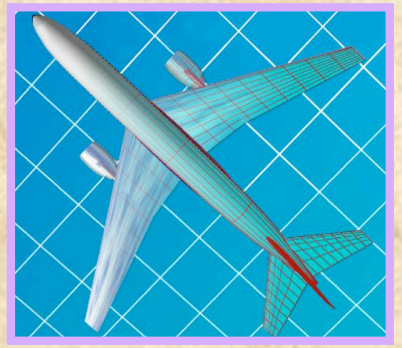
The development of aerospace vehicle and spacecraft concepts from a systems perspective to satisfy prescribed mission architectures and identification and prioritization of enabling technologies for performance, cost and safety

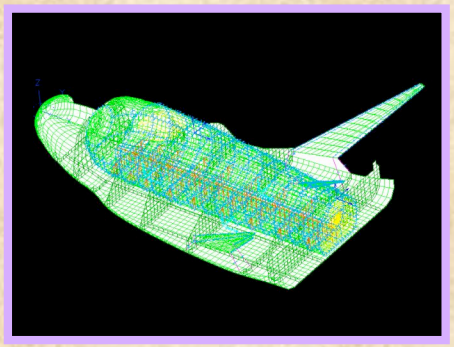


Products

- Conceptual design of advanced aerospace vehicle and spacecraft concepts
- System performance, cost, and risk analysis
- Enabling technologies and prioritization
- Technology investment portfolio

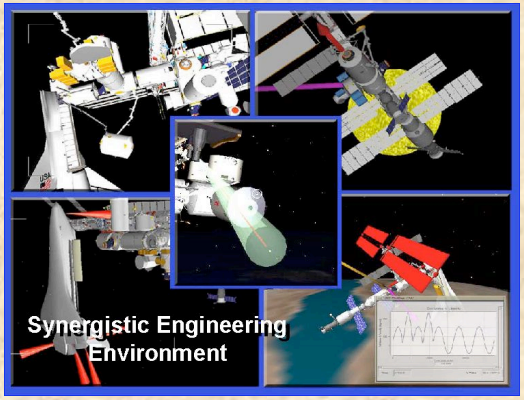






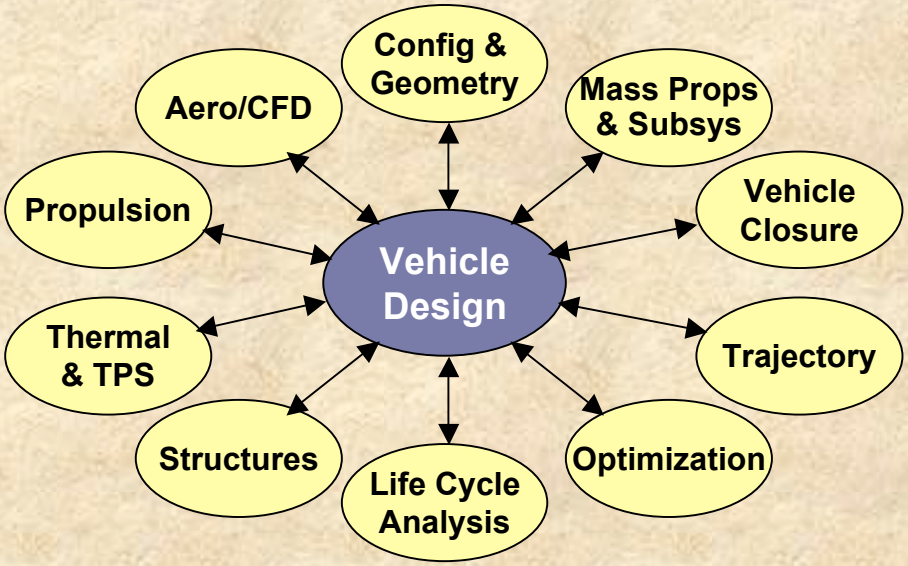
Advanced Analysis and Design Methods Development

Systems analysis and multidisciplinary design/optimization methods to enable mission planning and architecture, life cycle analysis, conceptual design of aerospace vehicles and spacecraft, and technology trades



Products

- Mission planning and architecture methods
- Systems analysis and design/optimization methods
- Life cycle analysis methods

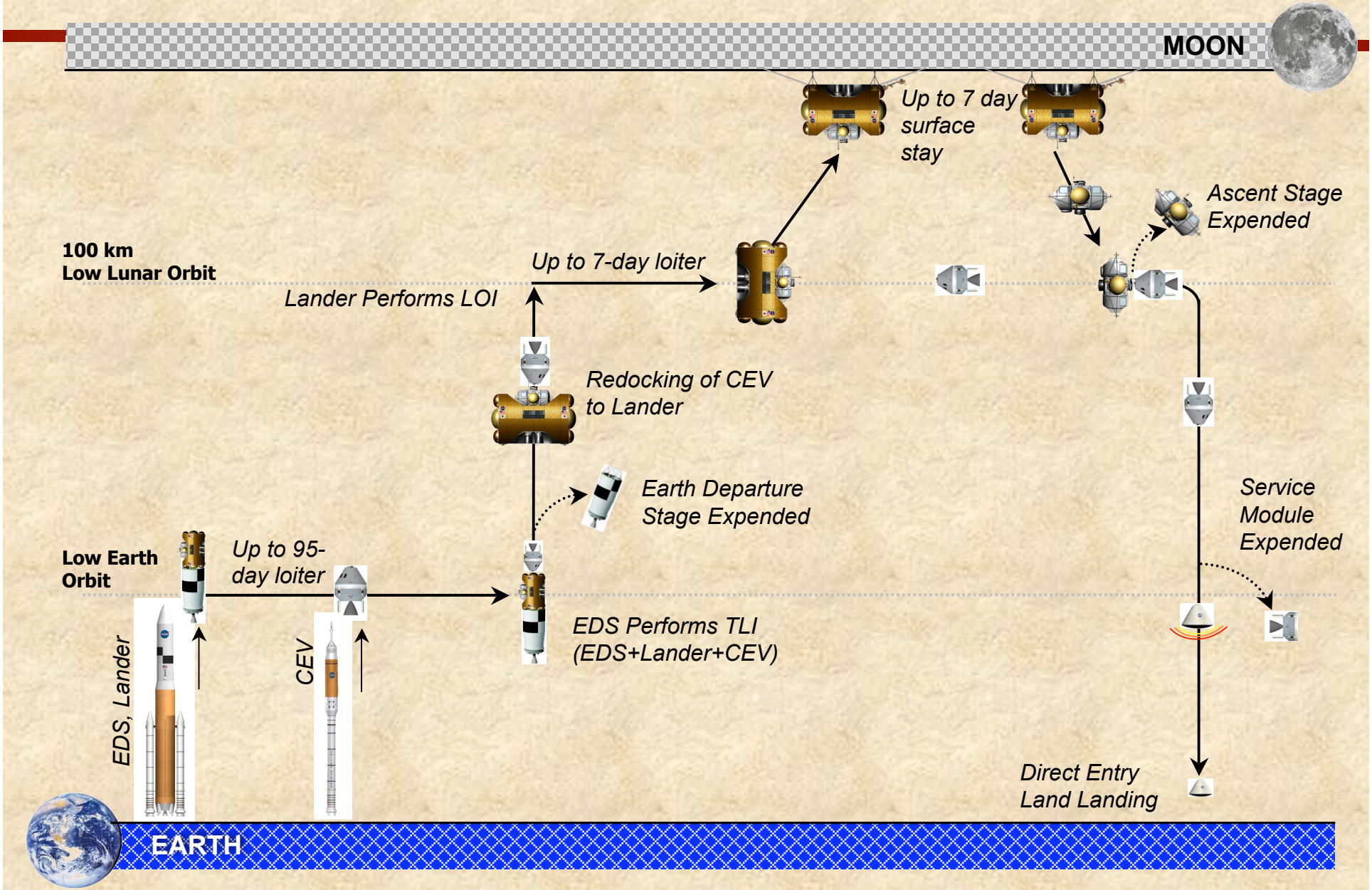


Systems Analysis Capabilities

- Systems Requirements Definition
- Mission Architectures, Concept of Operations, and Advanced Concepts Development
- Conceptual Vehicle Analysis and Design for Access to Space (Including Airbreathers)
- Trajectory Analysis and Optimization
- Stage Separation and Abort Analysis
- Systems Integration
- Capabilities and Technologies Assessment and Trades
- Life-Cycle Cost and Risk Analysis
- Space Communication Architecture
- Operational Analysis, e.g., Space Shuttle/ISS, EDL
- Integrated Design Center and Multimedia Laboratory

Langley has a heritage of pulling together resources from other NASA centers, academia, and industry to conduct aerospace systems analysis and provide unbiased information to the decision makers

A Lunar Mission Concept of Operations (Architecture)



Systems Analysis - Key Contributions

AERO

- Assessment of transformational operations concepts and vehicles
- Systems dynamics approach & "scale free network" analogies to model future NAS architectures
- Variable Fidelity Conceptual Design framework

Hyper-X

- Trajectory development

- Aerodynamic database
- Separation analysis
- Propulsion flow-path development

- Vehicle design & packaging
- Mishap investigation
- Successful mission

HL20

- Detail design, analysis & simulation
- Cost & manufacturing assessments
- Full scale mockup developed

OSP

- Feasibility on utilization of EELV for launch
- Evaluations of advanced concepts & technologies

NGLT

- Independent assessments of industry proposed launch system architectures
- Evaluations of adv. concepts & technologies

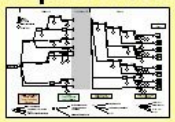
ISS

- Space Station concept development and redesign activities

- Risk mitigation & systems evolution assessments
- Communication

- ISS VIPER analytical support (SEE)

Exploration



- Assessed two broad Lunar Mission Scenarios
- Assessed modular systems for exploration
- Performed campaign and technology analysis
- Defined and evaluated lunar lander concepts

NEXT & Space Architect

- Advanced exploration architectures & systems concepts

ESAS

- Assessed ISS completion and Shuttle retirement
- Formulated ISS transportation strategies post Shuttle retirement
- CEV/ISS logistics carrier concepts

- Performed Lunar Surface Access Module trades and analysis

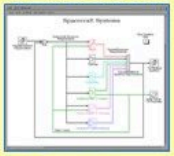
- Identified key technologies required for exploration systems

Odyssey & MER

- Provide flight simulations of aerobraking mission phase
- Recommend corrective maneuvers & model updates

- Trajectory, Multi-body simulations
- Aerodatabase
- Ballistic range stability tests
- Aeroheating
- Parachute wind tunnel tests
- EDL Sys Eng

Science Proposal Evaluation



- Proposal evaluation via mission simulation

Customers: Aeronautics, Exploration, Science, Operations, External

Air Transportation

Space Access

Earth's Neighborhood

The Moon

Mars

Beyond

Summary of Key Points

- Our technology is information and knowledge
- We specialize in innovative thinking
- Our work spans from strategic assessments to conceptual/preliminary design
- Pre-decisional information that we create impacts programmatic, budgetary, and technology decisions.
- A strong teamwork & customer/product focus is our hallmark

Working together

Our capabilities can support your decision making with respect to mission and architecture analysis, advanced system concepts Development, system and technology trades, life cycle cost and risk analysis, and system integration

Contacts

National Aeronautics and Space Administration

Dr. Ajay Kumar
Director
Systems Analysis and Concepts Directorate

NASA Langley Research Center
Mail Stop 449
Bldg. 1209 Rm. 132
Hampton, Virginia 23681

Office: (757) 864-1933
Fax: (757) 864-1649
Ajay.Kumar-1@nasa.gov

National Aeronautics and Space Administration

Long Yip
Systems Analysis and Concepts Directorate

NASA Langley Research Center
Mail Stop 449
Bldg. 1209 Rm. 157
Hampton, Virginia 23681

Office: (757) 864-3866
Fax: (757) 864-1649
Long.P.Yip@nasa.gov

If you have further questions today, please see a Partnership Consultant (look for a Bright Yellow badge) or visit the booth on How To Work With Langley